F I V E

HAZARD CHARACTERIZATION AND EXPOSURE ASSESSMENT

5.1 BACKGROUND

In practical terms, hazard characterization and exposure assessment are the first two steps in the four-step medical surveillance process. The last two steps (medical monitoring and epidemiologic analysis) are discussed in Chapter 9, "Medical Surveillance." Hazard characterization and exposure assessment are "preventive" steps in the sense that if properly performed they may lessen the need for medical monitoring followup (see Figure 5-1).

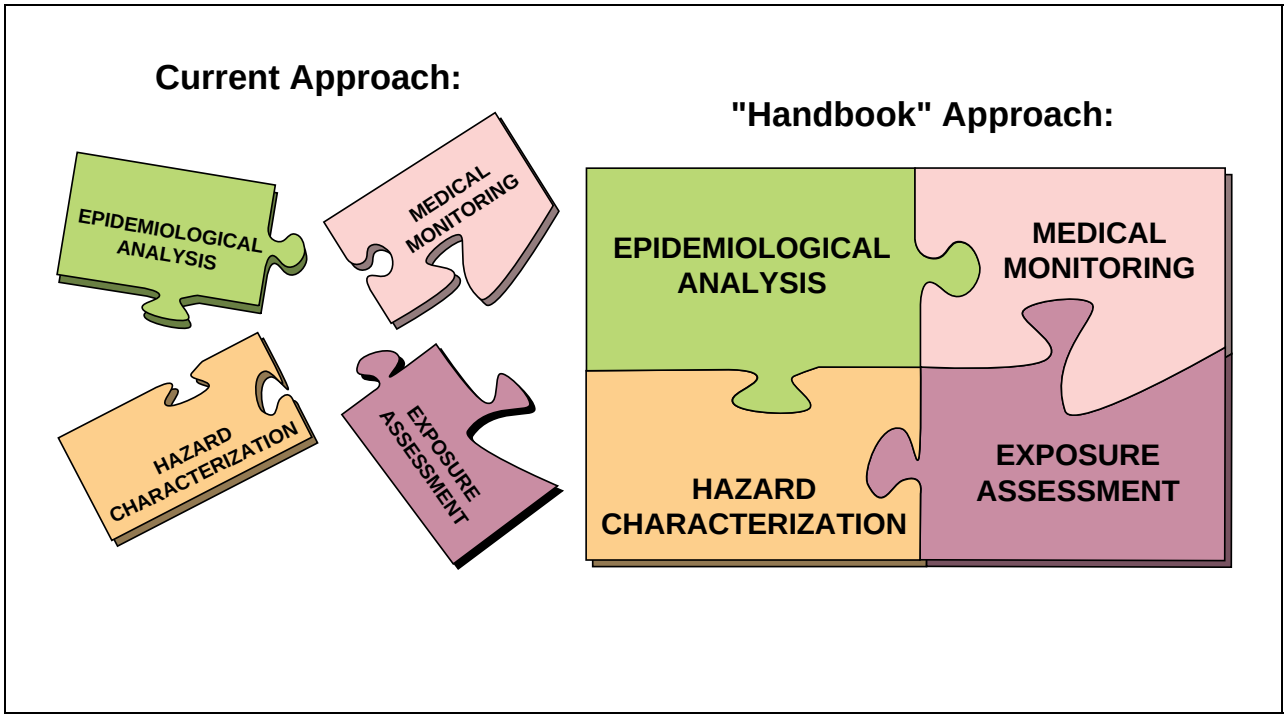

Figure 5-1. Medical Surveillance for Worker Protection

Hazard characterization and exposure assessment are core activities that integrate reliable and effective hazard analysis into work planning. They positively impact the work planning process and establish the access and hazard controls necessary to:

> *"Every aspect of the project's scope, schedule, and budget is affected by the results of the hazard characterization and exposure assessment."*

- Maintain worker health and safety and minimize or eliminate worker risk;
- Manage the scope and application of 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response" (the HAZWOPER Standard); and

- Allow work to continue without interruption by reducing surprises and worker over-exposure that delay work.

As illustrated in Figure 5-2, hazard characterization and exposure assessment are integral to the process of work planning and job conduct. They use a multidisciplinary team composed of Department of Energy (DOE) management and contractors, health and safety professionals, and worker representatives to identify, evaluate, and develop control measures for all chemical, physical, and biological hazards at the worksite.

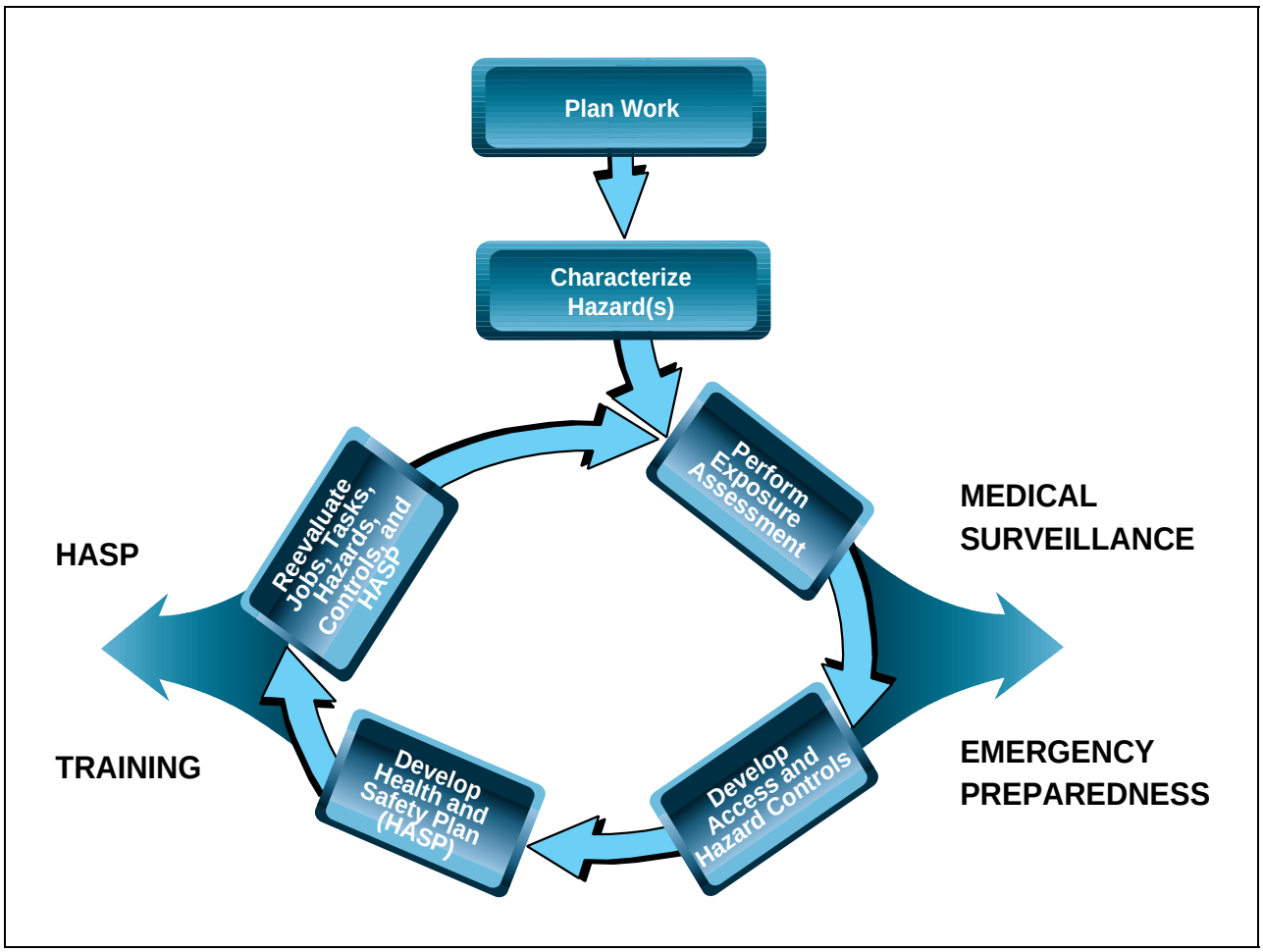

Figure 5-2. Hazard Characterization and Exposure Assessment Continuum

Hazard characterization uses job, task, and hazard analysis (JTHA) as its principal hazard analysis technique. JTHA involves examination of the hazards and exposure potential associated with a job or a task. It is an important step because it allows workers to be grouped so that risks and exposures experienced by any member of the group are representative of the group as a whole. Information about the nature of the workplace, the equipment and materials used, and the jobs and tasks to be performed is the basis of JTHA. To promote efficiency, the JTHA also uses information from all existing hazard analysis documentation, such as the safety analysis report (SAR), the process hazard analysis, the job safety analysis (JSA), and the job hazard analysis (JHA).

In the past, exposure assessment has used traditional industrial hygiene and health physics techniques to monitor and sample the workplace to detect the types and concentrations of potentially harmful substances. The multidisciplinary approach outlined here expands exposure assessment to include physical and biological hazards as well as chemical hazards. This approach is particularly applicable to highly dynamic workplaces such as hazardous waste cleanup sites where hazards are numerous and varied and exposures episodic.

Section 3162 of the 1993 Defense Appropriation Act requires DOE to establish occupational health programs to identify potential health hazards, characterize exposures, and medically monitor significantly exposed employees. The hazard characterization and exposure assessment steps discussed in this chapter and the medical monitoring and epidemiologic steps discussed in Chapter 9 meet these requirements.

5.2 MULTIDISCIPLINARY TEAM APPROACH

At the earliest work planning stages, the project manager establishes a multidisciplinary team to develop integrated hazard characterization and exposure assessment. It is essential that the team's roles and responsibilities, necessary project interfaces, and communication methods be carefully defined. The formation of this multidisciplinary team, which includes managers, health and safety professionals, professionals from other technical disciplines, and worker representatives, is essential for successful project execution since every aspect of the project's scope, schedule, and budget is affected by the results of the hazard characterization and exposure assessment.

ROLES AND RESPONSIBILITIES

The project manager is responsible for:

- Providing all available site characterization information and data to the team;
- Coordinating the team's activities and conducting periodic team meetings;
- Verifying that all alternative hazard analysis methods and risk scenarios have been considered;
- Making certain that the results of the hazard characterization and exposure assessment are incorporated in the HASP and work plans and that this information is disseminated to workers and other appropriate personnel; and
- Maintaining the appropriate documentation.

Hazard Characterization and Exposure Assessment Team

Representatives selected as appropriate from the following functional areas and technical disciplines can serve as team members:

- DOE project management
- Contractor management
- Project scientist, engineer, and planner
- Industrial hygienist
- Health physicist
- Toxicologist
- Occupational health physician and nurse
- Other health care providers
- Nuclear safety engineer
- Environmental engineer
- Industrial safety engineer
- Site safety and health officer
- Worker representative

The function of the hazard characterization and exposure assessment team is to:

- Determine the applicability of regulatory requirements;
- Assist in gathering and interpreting site characterization information and data;
- Provide input to the work planning process;
- Develop a single integrated and comprehensive hazard analysis;
- Perform job and task breakdowns and review engineering drawings, process flow diagrams, and operational procedures to identify the possibility for worker exposure to hazards;
- Incorporate worker knowledge and insights of past jobs and tasks and their hazards into the hazard analysis;

Coordinating the Team's Efforts

Using a multidisciplinary team to conduct hazard characterization and exposure assessment is a relatively new approach within the complex, one that has been shown to be effective in addressing the unique combination of hazards that exist within DOE. Coordinating the characterization and assessment team's efforts is crucial so that all health and safety concerns are addressed. Especially important is the integration of occupational health physicians and nurses with industrial hygiene and industrial and nuclear safety specialists so that exposure assessment data "follow the worker."

- Develop access and hazard controls for all phases of the project; and
- Assist in preparation and revision of the HASP and work plans.

5.3 REGULATORY FRAMEWORK AND HAZARD ANALYSIS TOOLS

A number of DOE Orders and DOE-adopted regulations require hazard characterization and exposure assessment when workers are exposed to hazards. Some have requirements for various types of hazard analyses which can be used as tools for performing hazard characterization and exposure assessment.

Many of the regulations are very prescriptive regarding the type of characterization and assessment required for specific jobs and tasks. For example, the HAZWOPER Standard requires exposure assessment at initial site entry during site characterization and analysis (29 CFR 1910.120 [c][6]) and during operations (29 CFR 1910.120 [h]). The site-specific HASP required in 29 CFR 1910.120 (b)(4) includes exposure assessment requirements for individual jobs and tasks. 29 CFR 1910.1000 and other specific OSHA standards require air monitoring for individual substances (e.g., lead, cadmium, asbestos) when exposure exceeds certain action levels.

DOE O 440.1 requires that contractors prepare hazard analyses that evaluate the work associated with each phase of a construction project, identify all foreseeable hazards to which workers may be exposed, and specify planned protective measures. For each construction operation presenting hazards not experienced in previous project operations or for work performed by a different subcontractor, the construction contractor prepares this hazard analysis, which is approved prior to, and authorizes, commencement of the affected work.

The four important hazard analysis tools that are used in the hazard characterization and exposure assessment process are described in the following DOE Orders and adopted regulations:

- DOE 5480.19 requires integration of health and safety issues in JSAs and JHAs as part of conduct of operations;
- DOE 4700.1 and DOE 5480.23 describe the timing, content, format, and approval procedures for SARs, including criteria for determining the level of reporting required based on facility functions and potential accident risks; and
- 29 CFR 1910.119 and DOE-STD-3009-93 require a process hazard analysis for processes and operational facilities.

Because of the importance of the information in the JSA, JHA, SAR, and process hazard analysis to hazard characterization and exposure assessment, each is discussed in detail below.

JOB SAFETY ANALYSIS AND JOB HAZARD ANALYSIS

The JSA and JHA are job- and task-specific hazard analyses. They differ, however, in that the JSA is a more general type of analysis; the JHA is task specific and applies to the activity being planned and conducted in a specific area and time. Quick completion time with limited resource allocation makes JSAs a widely used tool that satisfies a large portion of the hazard analysis tasks at a site or facility. They are equally appropriate for dynamic activities like construction and for static activities like maintenance.

JSAs and JHAs

For many job- and task-based hazards, the hazard analysis begins with a simple JSA or JHA. For general trenching operations, the JSA would identify and specify controls for: (a) general excavation hazards; (b) noise and general safety hazards associated with heavy machinery; and (c) potential for nitrogen dioxide accumulation in the trenches from diesel emissions. For an individual trenching operation, the JHA would identify unique hazards and control measures for that specific trenching operation (e.g., traffic control requirements which would vary depending on the location of the trench). If the hazards are poorly understood or operational facility safety hazards are required to be analyzed, additional or more complex hazard analysis techniques are employed.

The JSA and JHA separate jobs and tasks, identify and evaluate both health and safety hazards, and specify minimum hazard control requirements. The JSA for a DOE operation is often a longstanding document based on categories of operations. JSAs and JHAs are kept on record for reference such that they do not have to be reevaluated every time an operation is conducted.

SAFETY ANALYSIS REPORTS

SARs identify all materials-related hazards and potential accidents associated with a facility's process systems, components, equipment, or structures; and establish design and operational means to mitigate these hazards and potential accidents. The SAR does not preclude nonradiation sources of hazards, and tends to focus on operational safety and public protection issues, but with some recent emphasis on worker health and safety. SARs provide DOE with safety information with which to plan and budget safety programs and to assess the safety implications of in-service experience and proposed modifications. They are a risk management tool that defines the final basis for safety and risk acceptance for operational facilities. SARs identify the dominant contributors to the risk of the facility so that these vulnerabilities can be better managed.

SARs

Information and data available from the SAR include:

- Applicable statutes, rules, regulations, and departmental orders;
- Site characteristics and facility description, including design of principal structures, processes, components, and engineered safety systems;
- Hazard analysis and classification of the facility and principal health and safety criteria;
- Hazardous material protection programs;
- Analysis of normal, abnormal, and accident conditions, including design basis accidents, assessment of risks, consideration of natural and human-made external events; and
- Assessment of contributory and causal events, mechanisms, and phenomena, including evaluation of the need for an analysis of beyond-design-basis accidents.

PROCESS HAZARD ANALYSIS

The second comprehensive approach used in predictive hazard analysis is process hazard analysis. A process hazard analysis is a detailed study of a process to systematically identify every possible hazard and potential accident scenario. Process hazard analysis is directed toward analyzing potential causes and consequences of catastrophic events such as fires, explosions, and major spills and releases of toxic or flammable chemicals. As is the case

with the SAR hazard analysis, process hazard analyses focus on processes, components, and engineered safety systems. A process hazard analysis is performed on processes covered by the chemical thresholds of 29 CFR 1910.119, OSHA's chemical process safety management regulation. DOE-STD-3009-93 is consistent with the OSHA approach. The chemical industry has expanded the hazard analysis techniques beyond the minimum OSHA requirements through innovative approaches such as the process safety code of management practices and Responsible Care®.

SARs and Process Hazard Analyses

SARs and process hazard analyses use several common analytical tools to identify hazards:

- Change analysis
- Fault tree analysis (FTA)
- What-if analysis
- Checklist analysis
- "What-if" checklist analysis
- Failure modes and effects analysis (FMEA)
- Hazard and operability studies (HAZOPS)
- Phase hazard analysis

5.4 HAZARD CHARACTERIZATION AND EXPOSURE ASSESSMENT STRATEGY

The interrelationship of the elements of the hazard characterization and exposure assessment strategy (EAS) is illustrated in Figure 5-3. The EAS is the conceptual scheme used to develop and implement an appropriate methodology for an overall worksite occupational exposure assessment. The EAS is used to develop an exposure assessment plan (EAP) or contribute to other documentation such as the HASP, the safe work permit (SWP), or the radiological work permit (RWP).

According to the American Industrial Hygiene Association (AIHA), the goals of the EAS are to:

- Assess exposures of all workers to all hazardous chemical, physical, and biological agents to determine the priority for response to further assess or to control workplace hazards;
- Gather qualitative and quantitative information to determine the acceptability, unacceptability, or uncertainty of worker exposures;
- Perform exposure monitoring to evaluate uncertain exposures, collect baseline data, perform compliance monitoring, assess the adequacy of control measures, and research the harmful effects of workplace exposures;
- Develop controls to correct unacceptable worker exposures; and
- Document assessments, decision making, outcomes, and the recommendations of exposure assessment programs.

The core hazard analysis technique used in hazard characterization and exposure assessment, JTHA, is described in Element 1. JTHA is the principal hazard analysis technique described in DOE's *Draft Occupational Health Hazard Exposure Assessment Handbook for Hazardous Waste Activities*.

The hazard characterization and exposure assessment team considers all health and safety hazards including those introduced to the site by remediation or stabilization technologies and equipment as well as those already present. The site map developed as part of the access and hazard control strategy and the HASP are used to denote where jobs and tasks are to be performed in relation to the locations of hazards and possible worker exposures.

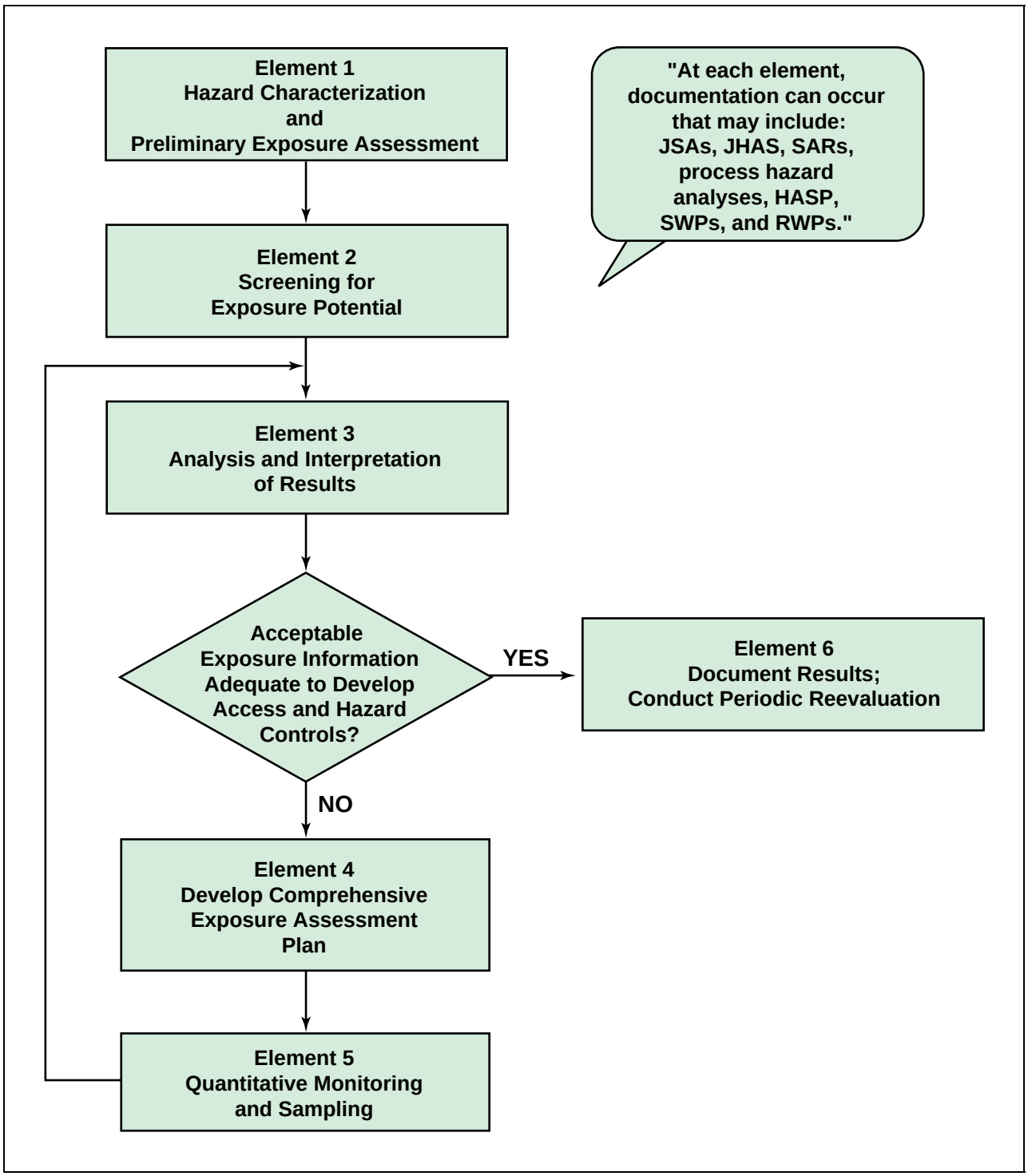

Figure 5-3. Hazard Characterization and Exposure Assessment Strategy

ELEMENT 1: HAZARD CHARACTERIZATION AND PRELIMINARY EXPOSURE ASSESSMENT

Hazard characterization consists of collecting, organizing, and analyzing the following information:

- *Site characterization information and data* from: site maps; air, soil, and water sampling data; material safety data sheets (MSDSs) and site inventories; accident, exposure, injury, and illness records; and interviews, inspections, and walkthroughs.

- *Hazard analysis and job and task information* from: JSAs, JHAs, SARs, and process hazard analyses; historical standard operating procedures or facility operating manuals; interviews with current and previous workers; and engineering designs and as-built drawings.

JTHA is the principal hazard analysis approach that meets the "job- and task-based" hazard analysis and control elements of the HAZWOPER Standard. It is a proactive and preventive methodology that provides a qualitative understanding of the relative possibility for worker exposure to hazards, linked to specific jobs and tasks. JTHA can support and be integrated with JSAs, JHAs, SARs, and process hazard analyses in the overall access and hazard control and health and safety planning process. JTHA is also used to aid in the identification of employee training requirements.

JTHA involves analysis of work in relation to hazard, risk, and possibility for worker exposure, which includes (1) identification of hazards; (2) identification of which jobs and tasks are associated with the hazards; and (3) identification of which jobs and tasks are directly associated with or linked to hazardous exposures. JTHA requires a review and observation of both routine and nonroutine jobs and tasks performed either by individuals or groups of individuals.

JTHA

JTHA asks, "Who will perform the work?" (the workers), "What is to be done?" (the job), "How is it to be done?" (the task); and "What are the associated hazards?" (the hazard). If a predominating or significant hazard is associated with the job, then hazard characterization and exposure assessment and access and hazard controls are focused at the job level without needing to analyze individual tasks. If the hazard or exposure potential is poorly understood or is believed to be associated with a task, then a more detailed or task-based analysis is required. In essence, JTHA integrates JSAs and JHAs, which focus on jobs and tasks, respectively.

The outcome of this element is to link hazards and their locations with specific jobs and tasks and to estimate possible worker exposures from the hazards.

When assessing the potential exposures, it is often efficient to assign workers to groups based on jobs and tasks that share common determinants of exposure (i.e., same or similar job functions and exposure conditions). Workers are assigned to similar exposure groups using information gathered during the hazard characterization. Methods should be documented to verify the validity of worker groups and worker exposure data. In practice, worker groups may contain one individual or many people with similar exposures.

ELEMENT 2: SCREENING FOR EXPOSURE POTENTIAL

Element 1 is a document review which essentially is a qualitative or preliminary hazard characterization and exposure assessment that may be sufficient to develop safe work plans and permits, or RWPs. Development of access and hazard controls and ultimately the HASP, for work associated with the ongoing project, generally requires that the characterization and assessment team visit the worksite to confirm the information and data collected in Element 1 and to perform screening measurements to substantiate exposure potential. These measurements are used to determine the possibility of hazardous exposures and to establish the scope of the comprehensive EAP that may be developed as part of the HASP.

The information from Element 1 is also used as a basis for (1) selection of personal protective equipment (PPE) for the initial site survey and (2) development of a preliminary HASP for initial site entry. In addition to the information obtained from Element 1, selection of PPE is also governed by the nature of the initial site activities to be performed. Level B protection is generally the minimum level recommended by EPA for initial site entry until worksite hazards and the most appropriate level of protection have been verified. The preliminary HASP documents procedures to protect the health and safety of the initial entry team. Probable worksite conditions should be the basis for establishing monitoring and investigation priorities. The initial entry team should consist

of two-person teams who will enter the worksite and two outside support persons who are wearing PPE and are prepared to enter the worksite in an emergency.

Screening Measurements and Diagnostic Monitoring and Sampling. Screening measurements are made in realtime using direct reading instruments (DRIs) and on an integrated basis using air sampling pumps and collection media for both chemical and radiological exposures. These measurements help to quantify:

- Point-source emissions and exposure groups; and
- Possible exposures and exposure ranges for specific jobs and tasks.

The early application of both DRI and sampling methodology may reduce the scope of Element 5, Quantitative Monitoring and Sampling.

Visual Observations and Checklists. Inspections and walkthroughs are an important component of Element 2; they serve to identify physical and biological hazards as well as to subjectively confirm health hazard information. Comprehensive checklists (such as the EM Managers Guide for Safety and Health Walkthrough) facilitate conducting inspections and walkthroughs.

DRIs and Sampling Instruments and Methodology

Descriptions of instruments and methodology for air monitoring and sampling at hazardous waste operations can be found in:

EPA Office of Emergency and Remedial Response, *Standard Operating Safety Guides,* National Technical Information Service (NTIS) Publication 9285.1-03.

Ness, Shirley A., *Air Monitoring for Toxic Exposures -- An Integrated Approach,* Van Nostrand Reinhold.

Lioy, Paul J. et al., *Air Sampling Instruments,* American Conference of Governmental Industrial Hygienists.

DOE Office of Worker Health and Safety, *Draft Occupational Health Hazard Exposure Assessment Handbook for Hazardous Waste Activities.*

ELEMENT 3: ANALYSIS AND INTERPRETATION OF RESULTS

As depicted in Table 5-1 and Figure 5-3, in many cases the results from Element 2 are sufficient to assess exposure and develop access and hazard controls for the HASP, SWP, or RWP. The hazard characterization and exposure assessment does not proceed beyond this element. The results are documented in the HASP, SWP, or RWP. Periodic reevaluations need to be performed (Element 6), especially if work or site conditions change.

Table 5-1. Example Analysis and Interpretation Outcomes

If . . .	Then . . .
1. Monitoring and sampling results indicate exposures are not above established exposure limits. 2. Radiation dose rates are near 10^{-6} rem or background. 3. Radionuclides are below free release limits (DOE 5480.5). 4. No safety hazards are present.	1. Health, safety, and radiological hazards do not pose the possibility for worker over-exposure. 2. The work does not require additional hazard characterization and exposure assessment. 3. Incorporate rationale for this decision into appropriate documentation (e.g., HASP, SWP, or RWP). 4. Conduct periodic reevaluation.
1. Monitoring and sampling results indicate exposures are above established exposure limits. 2. Radiation dose rates are above 10^{-6} rem or background. 3. Radionuclides are above free release limits (DOE 5480.5). 4. Safety hazards are present.	1. Worker exposures are potentially hazardous. 2. Proceed to Elements 4 and 5. Develop comprehensive exposure assessment plan (EAP), conduct quantitative monitoring and sampling, and analyze and interpret data. 3. Develop appropriate access and hazard controls and incorporate into the HASP, SWP, or RWP. 4. Conduct periodic reevaluation.

In other cases, the data collected from Element 2 indicate that a more comprehensive and quantitative exposure assessment plan (Element 4) is required. In either case, the outcome of Element 3 is a careful analysis and interpretation of Elements 1 and 2 with clear indication of the adequacy of the data and the need to proceed to Element 4.

ELEMENT 4: DEVELOP COMPREHENSIVE EXPOSURE ASSESSMENT PLAN

If the screening data indicate that comprehensive quantitative monitoring and sampling are needed, an EAP should be developed. The EAP includes the four questions of the JTHA (Who will perform the work? What is to be done? How is it to be done? What are the hazards?) and the quantitative monitoring and sampling that are to be done. The monitoring and sampling methodology is similar to that of Element 2, but quantitative and more comprehensive. Coordination with occupational medicine specialists may be required. The EAP should be incorporated into the HASP.

Sampling programs should specify AIHA-accredited laboratories, validated sampling and analytical methods, and appropriate occupational exposure limits (OELs). The criteria should identify the minimum number of samples and length of sampling period to characterize worker groups. Monitoring programs must also determine the need for specific sampling recommendations or random selection of workers and sample time periods. Workers are often stratified into exposure groups before individuals are randomly selected for monitoring.

ELEMENT 5: QUANTITATIVE MONITORING AND SAMPLING

Quantitative measurements are performed to characterize the magnitude and variability of worker exposures that cannot be adequately assessed using the information from Elements 1 and 2. Quantitative monitoring and sampling establish baseline data, document regulatory compliance, and inform management and workers of exposures.

Clear, concise records of monitoring and sampling are maintained to include the model and serial numbers of all equipment used, calibration data, and site conditions.

Typically, professional judgment is used to arrange workers in similar exposure groups and to interpret the monitoring results. Monitoring and sampling results are compared to OELs with appropriate averaging times and clear statistical definitions of over-exposure based on toxicological determinants. Interpretation of all results should be made by a competent person. The results of exposure monitoring may apply to other workers, depending on the exposure determinants and overall uncertainty of the sampling and analytical methodology.

Element 5 will likely continue throughout the course of the project. The scope of Element 5 will vary as the work progresses and will follow a hazard-based approach. For high-risk work with high exposure potential, a greater amount of monitoring and sampling is required, with a larger percentage of workers in the representative population. As the exposure potential decreases, the extent of monitoring and sampling can be relaxed, and the percentage of workers in the population can be reduced. The outcome of Element 5 should be the careful specification of access and hazard controls consistent with maintaining worker health and safety.

ELEMENT 6: DOCUMENT RESULTS; CONDUCT PERIODIC REEVALUATION

Throughout a project, data are obtained from both qualitative and quantitative exposure assessment, and the results are analyzed and interpreted. Ultimately, the hazard characterization and exposure assessment process will reach a point where the access and hazard controls are sufficient to maintain worker health and safety. If the exposures of individual workers or a group of workers are documented as acceptable, based on qualitative and quantitative exposure assessment, additional monitoring and sampling may not be necessary. If new hazards are introduced, or there is a significant change in the hazard potential, a reevaluation should be conducted as soon as possible after the change occurs.

Reevaluation involves reexamining the operation, using some or all of the elements of the EAS, and exercising professional judgment. Even if there is no significant change in the operation, periodic reevaluation is needed

to ensure that the exposures do not change over time. The frequency of reevaluation should be based on the length of the entire hazardous waste activity and the type of hazards which have been encountered in the past or might be encountered in the future. Foremost, the level of exposure may determine the frequency of reevaluation. In addition, reevaluation may be triggered by the introduction of new hazardous materials, modification of workplace controls, changes in process conditions or work practices, or new toxicological information or regulatory standards.

Construction or Mobile Workers. Exposure assessment for construction workers is of great concern because of their high degree of mobility between DOE sites and facilities. For this reason, occupational health physicians and nurses should be involved in the EAS when these types of workers are involved. The need for periodic reevaluation increases as a function of the number of additional construction or mobile workers.

5.5 DOCUMENTATION

Proper documentation and control of documents facilitate accurate communication, ensure the quality of the information collected, provide the basis for safety decisions, support decisions in emergency situations, and substantiate possible legal actions. Information obtained from the hazard characterization and exposure assessment process should be initially recorded in one or more of the following forms:

- Logbooks;
- Field data records;
- Instrument print-outs;
- Photographs;
- Sample labels;
- Chain-of-custody forms; and
- Analytical records.

Ultimately, documentation appears or is referenced in the HASP, SWP, or RWP. All documents should be controlled and accounted for when the project is completed. Document control should be the responsibility of a member of the project team. Field personnel should record all worksite activities and observations in a field logbook; entries should be made during or immediately following a task.

DOE has developed a job- and task-code system to facilitate correlation between data collected and workers, jobs, and tasks. This system appears in the DOE Office of Worker Health and Safety, *Draft Occupational Health Hazard Exposure Assessment Handbook for Hazardous Waste Activities*. Information on the chemical, physical, and biological properties of each hazard known or expected to occur at the worksite should also be documented.

5.6 REFERENCES

29 CFR 1910, "Occupational Safety and Health Standards for General Industry"

29 CFR 1910.119, "Process Safety Management of Highly Hazardous Chemicals"

29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response"

29 CFR 1926, "Safety and Health Regulations for Construction"

DOE 5480.19, "Conduct of Operations Requirements for DOE Facilities"

DOE 5480.23, "Nuclear Safety Analysis Reports"

DOE-STD-3009-93, "Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Report (Area SAFT)"

DOE-ID (76-45/19 SSDC-19), "Job Safety Analysis by Division of Operational and Environmental Safety"

DOE Office of Worker Health and Safety, *Draft Occupational Health Hazard Exposure Assessment Handbook for Hazardous Waste Activities*

Draft DOE/EH Guideline, "Preliminary Guide for Conformance with OSHA's Rule for Process Safety Management of Highly Hazardous Chemicals"

ACGIH, "Threshold Limit Values for Chemical Substances and Physical Agents, and Biological Exposure Indices"

American Conference of Governmental Industrial Hygienists (ACGIH), "Documentation of the Threshold Limit Values and Biological Exposures Indices"

American Industrial Hygiene Association, "A Strategy for Occupational Exposure Assessment"

EPA Office of Emergency and Remedial Response, *Standard Operating Safety Guides,* National Technical Information Service (NTIS) Publication 9285.1-03

Leidel, N.A., K.A. Busch and J.R. Lynch. National Institute for Occupational Safety and Health (NIOSH) Publ. 77-173, *Occupational Exposure Sampling Strategy Manual*

Lioy, Paul J. et al., *Air Sampling Instruments,* American Conference of Governmental Industrial Hygienists

Ness, Shirley A., *Air Monitoring for Toxic Exposures -- An Integrated Approach,* Van Nostrand Reinhold

OSHA, *Field Operations Manual*

Section 3162 of the 1993 Defense Appropriation Act

U.S. Department of Labor Mine Safety and Health Administration (MSHA) Instruction Guide 32 C, "Job Safety Analysis Development by National Mine Health and Safety Academy"